REMARKS

Claims 1-5, 11-16, 19-26 and 31 are pending herein. Claims 6-10, 17-18 and 27-30 have been canceled herein without prejudice or disclaimer.

1. Claims 1-9 were rejected under §103 over Grabmaier et al. in view of Robinson et al. This rejection is moot in view of the amendments to the present claims.

2. Claims 1-4, 6-20, 22-31 were rejected under §103 over Schmid in view Robinson et al. This rejection is respectfully traversed for the following reasons.

The claimed invention (claim 11) is drawn to a method for forming single crystal spinel wafers from a single crystal boule. As recited, the method calls for growth of a boule from a batch melt at a process aspect ratio of not less than 0.39, the process aspect ratio being defined as a ratio of average boule diameter to crucible inside diameter. Of particular significance, in addition to boule growth at the above-noted process aspect ratio, the boule has a non-stochiometric composition, having a b:a ratio greater than 1:1 such that the spinel is rich in E_2D_3. The particular combination of features, notably, minimum process aspect ratio and non-stochiometric composition being rich in E_2D_3, is of particular significance. As described throughout the present specification, the combined features provide for successful growth of boules having a desired crystallographic orientation (i.e., a non-flipped [1 1 1] orientation). Moreover, the claimed method provides for a boule that may be sliced without cracking even with very limited cool down periods and virtually no anneal periods. By way of example, a comparative stochiometric spinel boule typically requires a cool down period on the order of 300 hours, followed by excessive annealing time periods. In contrast, boules grown according to the claimed process may be cooled for relatively short time periods, such as on the order of 8 hours, while virtually eliminating the entire anneal step. See paragraphs 34-38 of the present specification for additional information.

Turning to the cited prior art, the PTO has relied upon Schmid for a basic process flow of a stochiometric spinel ($MgAl_2O_4$), and on Robinson et al. for disclosure of slicing of boules into wafers. As correctly noted by the PTO, the prior art references Schmid and Robinson et al. do not teach forming a non-stochiometric spinel. However, in an attempt to meet this claim feature, the PTO has reasoned that non-stochiometric spinel crystals are known in the art as evidenced by Grabmaier et al., and that a non-stochiometric composition is an obvious variant of a stochiometric composition. However, Applicants respectfully disagree. As described in detail above, the claimed feature of a non-stochiometric spinel being rich in E_2D_3 is of notable significance. Applicants have developed the claimed process in order to facilitate formation of relatively large boules, such as on the order of 2 inches in diameter and above, by a process that does not require extensive cool down and annealing time periods thereby increasing throughput. In addition, the claimed compositional features contribute to a marked reduction in boule fracture thereby improving yield.

Although the disclosure of Grabmaier et al. has not been expressly relied upon by the PTO in the context of the present rejection, the reference made to Grabmaier et al. by the PTO merits comment. Grabmaier et al. teach the growth of a boule from a 3:3.2 non-stochiometric melt and also reports that crystals from the melt were confirmed to be single crystals. However, Grabmaier et al. go on to disclose that crystals grown from the 3:3.2 melt have various lattice constants for lattice parameters a and b. While Grabmaier et al. attempt to explain away the existence of the multiple lattice constants, the varying lattice constants indicate a polycrystalline boule, and accordingly, polycrystalline wafers. In contrast, the claimed invention is drawn to single crystal wafer fabrication. Stated another way, the varying lattice constants means a polycrystalline boule, which is outside the scope of the present invention.

Further, it appears that the PTO is generally relying upon the disclosure of Grabmaier et al. for teaching that both stochiometric and non-stochiometric spinels may be grown and sawed without annealing. However, this is in direct contrast to Applicants' own technical studies, in that stochiometric (1:1) boules must be cooled over a lengthy time period (e.g., 300 hours), followed by an extensive anneal period. While Grabmaier et al. appear to broadly state that both types of crystals may be sawed without annealing, that statement is made with respect to diminutive boules that are of no commercial interest, that is, lab-bench sized boules. More specifically, the industry calls for to 2.0"+ wafers derived from 2.5"+ boules, and the boule size of Grabmaier et al. is notably less than 1.5" in diameter, most likely on the order of 1.0" diameter and smaller (representing a mere 25% of the mass of a 2" boule). Perhaps the low mass lab bench trial of Grabmaier et al. is responsible for the reported ability to saw boules without annealing; nevertheless, it is quite clear that Applicants have discovered that the non-stochiometric composition as claimed is of notable significance as combined with high process aspect ratio processing, and that the claimed non-stochiometric wafer processing cannot in any manner be considered equivalent to stochiometric (1:1) wafer processing. The art of record including Grabmaier et al., do not even remotely recognize the clear distinctions and advantages of non-stochiometric E_2D_3 rich processing, including throughput and yield, and clearly the art does not teach or enable single crystal processing from a non-stochiometric melt as already noted above.

Since the prior art references fail to disclose or suggest melt processing of single crystal spinel wafers utilizing characteristic process aspect ratio and compositional features, Applicants respectfully submit that the art rejection over Schmid and Robinson et al. is deficient and should be withdrawn.

3. Claims 23-30 were rejected under §103 over Geiss et al. in view of Robinson et al. This rejection is moot in view of the amendments to the present claims.

4. Claims 10-20 and 22 were rejected over Wyon et al. in view of Robinson et al. This rejection is respectfully traversed for the following reasons.

In a nutshell, this rejection is deficient for the same reasons stated above with respect to the art rejection over Schmid and Robinson et al. The combined references of Wyon et al. and Robinson et al. fail to teach or even remotely suggest a melt-based process for forming single crystal spinel wafers combining process aspect ratio and compositional features as claimed. With respect to the compositional features, the PTO has stated that disclosed $Mg_{1-x}Ni_xAl_2O_4$ crystal is non-stochiometric. However, this is not the case. The composition of Wyon et al. merely partially substitutes Ni for Mg. Nevertheless, the crystal is stochiometric, having a 1:1 ratio of Mg(Ni)O to Al_2O_3. Further, modification of the processes disclosed by Wyon et al. and Robinson et al. to utilize a non-stochiometric composition would not have been obvious, and indeed, use of a non-stochiometric composition as claimed is of particular significance as described in detail above.

For at least the foregoing reasons, Applicants respectfully submit that the §103 rejection over Wyon et al. in view of Robinson et al. is deficient and should be withdrawn.

5. Claim 21 was rejected under §103 over Wyon et al. in view of Robinson et al. and Lee. Lee fails to overcome the deficiencies of the references discussed above, and accordingly, this rejection should be withdrawn as well.

Applicants respectfully submit that the present application is now in condition for allowance. Accordingly, the Examiner is requested to issue a Notice of Allowance for all pending claims.

Should the Examiner deem that any further action by the Applicants would be desirable for placing this application in even better condition for issue, the Examiner is requested to contact Applicants' undersigned attorney at the number listed below.

The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 50-2469.

Respectfully submitted,

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Jeffrey S. Abel, Reg. No. 36,079
Attorney for Applicant(s)
TOLER, LARSON & ABEL, L.L.P.
5000 Plaza On The Lake, Suite 265
Austin, Texas 78746
(512) 327-5515 (phone)
(512) 327-5452 (fax)